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Coronary Artery Obstruction After the Arterial Switch Operation for Transposition of the Great Arteries in Newborns

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Objectives. **We sought to describe a large series of coronary artery obstructions after the arterial switch operation for transposition of the great arteries and to discuss their clinical implications.**

Background. **Aortic root angiography and myocardial perfusion imaging yield ambiguous results regarding the fate of the coronary artery anastomoses after the arterial switch operation. Late death related to coronary artery obstruction and growth of the translocated coronary arteries are of major concern in these patients.**

Methods. **Selective coronary artery angiography was performed prospectively in a total of 165 children.**

Results. **A total of 12 coronary occlusions, 8 major stenoses, 6 minor stenoses of the left ostium and 4 stretchings of one coronary artery were identified. Obstructions were more frequent in types D and E ($p < 0.001$) of the Yacoub and Radley-Smith classification. Coronary obstruction was documented in all patients with electrocardiographic and ultrasound evidence of myocardial ischemia at time of study. Early postoperative ischemia did not predict coronary artery lesion if the patient had fully recovered. Persistent or delayed myocardial ischemia was highly predictive of coronary artery lesions. The incidence of coronary artery obstruction was very high (11 of 35) in patients operated on by a rapidly abandoned technique of single-orifice reimplantation of both coronary artery ostia.**

Conclusions. **Selective coronary angiography is the most accurate means to assess coronary artery obstruction after the arterial switch operation. Precise diagnosis of coronary artery lesions after this operation will help to elucidate the pathogenesis, develop adequate therapeutic strategies and might indicate how to prevent coronary complications after operation.**

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The arterial switch operation has become the treatment of choice for neonates with transposition of the great arteries (1–3). In selected institutions, operative mortality is low and appears to be predominantly related to coronary artery obstruction (4,5). Midterm results remain excellent with a low incidence of the two previously reported complications, namely aortic valve regurgitation and supravalvar pulmonary stenosis (6,7).

However, the fate of the coronary artery anastomoses remains a matter of debate (8). Recently, aortic root angiographic studies (9) and myocardial perfusion studies (10) yielded ambiguous results concerning coronary artery patency after the arterial switch operation.

In a previous study (11), we determined the incidence of late coronary artery obstruction after the arterial switch operation in a homogenous group of patients to be 7.8%. Here, we report on the results of selective coronary angiography carried out in a heterogenous group of 165 children after the arterial switch operation. Coronary artery obstruction was documented in 30 patients. We attempted to classify the various types of coronary artery lesions encountered and to correlate them with noninvasive variables.

Methods

Patients. Since 1984, all patients with transposition of the great arteries referred to our institution during the neonatal period underwent complete repair by the arterial switch operation (12). The operations were performed by six different surgeons in four institutions. In addition, from 1992 to 1993, a particular technique of coronary artery translocation in which both coronary artery ostia were reimplanted together in a single orifice (13) was used. It is of note that coronary anatomy never constituted an argument in favor of atrial repair in our experience. Today, 387 survivors after arterial switch operation are followed up in our institution.

One hundred sixty-five patients underwent selective coronary angiography (mean [±SD] age 5.71 ± 3.49 years, range 2 weeks to 15 years; mean weight 20.8 ± 10.9 kg, range 3 to 70). One hundred thirty-five had single-stage repair for isolated transposition of the great arteries: 24 for transposition of the

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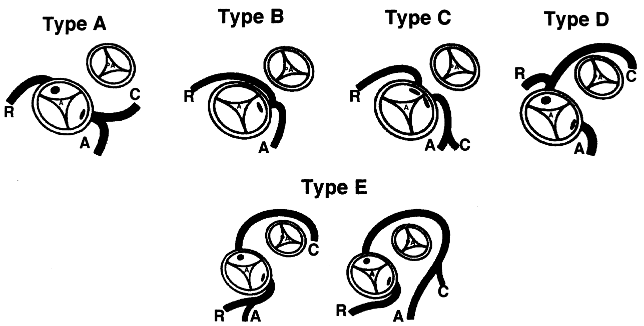

Figure 1. The various types of coronary artery distribution in transposition of the great arteries (classification of Yacoub and Radley-Smith [14]). A = left anterior descending coronary artery; C = circumflex coronary artery; R = right coronary artery.

great arteries plus ventricular septal defect, 6 for transposition of the great arteries plus coarctation of the aorta. Coronary anatomy was classified according to the classification of Yacoub and Radley-Smith (14) (Fig. 1) and was type A in 107 patients (64.8%), type B in 7 (4.2%), type C in 6 (3.6%), type D in 34 (20.6%) and type E in 11 (6.7%).

Selective coronary angiography was performed for one of the following reasons: 1) In 25 patients operated on with a usual technique for coronary artery transfer, electrocardiographic (ECG) or echocardiographic findings, or both, suggested myocardial ischemia (mean age 3.70 ± 3.27 years, range 2 weeks to 9.5 years); 2) 105 patients were included in a prospective study in which we sought to determine the long-term patency (minimal follow-up 5 years) of the coronary artery anastomoses in children who underwent an anatomic repair for transposition of the great arteries (mean age 7.61 ± 2.41 years); 3) because we observed an unusual and alarming incidence of ischemic events in patients operated on with the single-orifice technique, we performed an early control study of the coronary arteries in all of them (n = 35).

Functional status. Patient evaluation included perioperative history, clinical examination, 12-lead rest ECG, echocardiogram and exercise testing after 5 years of age. Pertinent perioperative items were 1) early postoperative ischemic events related to coronary artery translocation; 2) early reintervention for ischemic complications; 3) myocardial ischemia or infarction; and 4) left ventricular failure with prolonged inotropic support (>3 days).

Clinical evaluation included identification of cardiac failure, chest pain and a complete clinical examination. Echocardiographic studies evaluated left ventricular systolic dysfunction, reduction of segmental wall motion, hyperechogenicity of a papillary muscle of the mitral valve and mitral valve insufficiency. Treadmill exercise testing was performed using a modified Bruce protocol with 12-lead ECG monitoring. All tracings obtained before exercise, at each stage of exercise and during recovery were reviewed by one of us (D.B.). Myocardial perfusion imaging (thallium) was performed in 23 of 30 patients with coronary artery obstruction. We suspected myocardial ischemia when ST-T anomalies or Q waves were present on the ECG or when the ultrasound studies showed one of the above-mentioned abnormal findings, or both.

Coronary artery angiograms. Catheterization was undertaken under local anesthesia using the femoral artery approach. Because of the anterior position of both newly implanted coronary ostia, selective coronary artery angiography was performed exclusively with right coronary catheters (Cordis; Cook, Bjaeverfkov, Denmark) between 4F and 5F and various curvatures (Judkins 1.5, 2, 2.5, 3.5, 4). The two smaller sizes were made available on specific order (Cordis, Viry-Chatillon, France).

The coronary artery orifices were sought in lateral view, with the distal part of the catheter positioned anteriorly on the aortic wall. After the coronary artery orifice was entered, coronary angiography was performed by manual injection. Particular attention was paid to the opacification of the coronary artery orifice. Coronary artery angiograms were considered satisfactory only when good opacification of the coronary artery ostium was obtained. The angiogram for the coronary artery arising from the left side of the neoaortic root was obtained in the right anterior oblique view (20°); for the coronary artery arising from the right side, a left anterior oblique view was used (20°).

Coronary artery obstructions were classified as *occlusion*, *major stenosis* (>50% coronary artery diameter reduction), *minor stenosis* (<50% coronary artery diameter reduction) and *stretching of one coronary artery*. The presence of collateral vessels arising from the other coronary artery were carefully traced.

Statistical analysis. Summary statistics are presented as mean values ± SD and range. An unpaired Student *t* test or chi-square analysis was used to evaluate possible differences for between-group comparisons. Percentages are presented with 95% confidence intervals. Statistical significance was assessed by using a cutoff p value of 0.05.

Results

We encountered four complications during catheterization: transient myocardial ischemia during injection of contrast medium in the main left coronary artery in three patients and hematoma at the site of puncture in one patient. No patient had evidence of ventricular arrhythmia, coronary thrombosis, systemic embolization or femoral artery occlusion during or after the procedure.

Coronary obstruction was detected in 30 patients (Table 1): occlusion of the left coronary artery in 9 (Fig. 2), occlusion of the circumflex artery in 3, major stenosis of the left ostium in 7, major stenosis of the right ostium in 1, minor stenosis of the left ostium in 6 and stretching of one coronary artery looping around one of the great vessels in 1.

When the origin and epicardial course of the coronary artery were considered, the incidence of coronary artery obstruction was more frequent when one of the main coronary arteries looped around the great vessels (types D and E) than in other types of Yacoub's classification (chi-square 6.57, $p < 0.001$). In two

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Figure 2. Left ostium occlusion with collateral vessels from the right coronary artery (Patient 18).

patients (Patients 16 and 17), the initial course of the left main coronary artery was intramural, and selective angiography showed an occlusion of the left ostium in these two patients.

The risk of coronary artery obstruction according to the technique of translocation of the coronary artery was significantly higher for the single-orifice technique (11 of 35 vs. 19 of 130, chi-square 5.25, $p < 0.01$). Because the incidence of coronary artery obstruction is very high in this group, the results are presented separately.

Standard operative technique: coronary artery obstruction versus myocardial ischemia. Twenty-five patients had either ST-T changes (n = 14) or Q waves (n = 6) on ECG or at least one abnormal echocardiographic finding suggesting myocardial ischemia (n = 19). Of these 25 patients with evidence of myocardial ischemia at the time of cardiac catheterization, 13 (52%, 95% confidence interval [CI] 32% to 71.9%) exhibited ECG and echocardiographic anomalies. All had coronary artery obstruction: occlusions in 7, major stenosis of the left ostium in 4, minor stenosis of the left ostium in a child with perioperative myocardial infarction and stretching of the left main coronary artery with type B anatomy in 1. In the remaining 12 patients, myocardial ischemia was suspected on the ECG or echocardiogram: All had normal coronary arteries.

Table 1. Patients With Coronary Artery Obstruction

Pt No./Age	Coronary Distribution*	Operative Technique	Periop MI	ECG	Echo	Exercise Test or Myocardial Scintigraphy	Coronary Artery Lesion
1/2 wk	A	SO	−	+	−	Perfusion defect	LO occlusion
2/2 wk	D	SO	+	+	+	0	Cx stretch
3/2 wk	E	SO	+	+	+	Normal	Cx stretch
4/2 wk	B	Usual	+	+	+	0	LCA stretch
5/2 wk	E	SO	−	+	+	Normal	Cx occlusion
6/2 wk	A	Usual	+	+	+	0	Min LO stenosis
7/2 wk	D	Usual	−	+	+	0	Sig LO stenosis
8/4 mo	A	SO	−	+	+	0	Sig LO stenosis
9/5 mo	E	Usual	−	+	+	0	LO occlusion
10/7 mo	A	Usual	−	+	+	Perfusion defect	Sig LO stenosis
11/1 yr	E	SO	−	−	−	Perfusion defect	Sig RO stenosis
12/1 yr	D	SO	−	−	−	Normal	Sig LO stenosis
13/1 yr	D	Usual	−	+	+	Perfusion defect	Sig LO stenosis
14/1.1 yr	C	SO	−	−	−	Normal	Min LO stenosis
15/2.3 yr	D	SO	−	−	−	Perfusion defect	Sig LO stenosis
16/2.5 yr	C	SO	−	−	−	Perfusion defect	LO occlusion
17/2.7 yr	D	Usual	+	+	+	0	LO occlusion
18/2.8 yr	A	SO	−	+	+	Perfusion defect	LO occlusion
19/4.5 yr	D	Usual	+	+	+	Perfusion defect	LO occlusion
20/4.7 yr	A	Usual	−	−	−	Negative	Min LO stenosis
21/4.8 yr	A	Usual	+	+	+	Negative	LO occlusion
22/5.1 yr	D	Usual	+	+	+	Negative	Cx occlusion
23/6.9 yr	A	Usual	−	−	−	Negative	Min LO stenosis
24/7.0 yr	D	Usual	+	+	+	Negative	Cx occlusion
25/7.1 yr	A	Usual	−	+	+	Perfusion defect	Sig LO stenosis
26/7.3 yr	E	Usual	+	−	−	Negative	Cx stretch
27/7.7 yr	A	Usual	−	−	−	Negative	Min LO stenosis
28/8.0 yr	A	Usual	−	−	−	Negative	Min LO stenosis
29/9.5 yr	A	Usual	+	+	+	Perfusion defect	LO occlusion
30/9.7 yr	A	Usual	−	−	−	Negative	LO occlusion

*Classification according to Yacoub and Radley-Smith (14). Cx = circumflex coronary artery; ECG = electrocardiography; Echo = echocardiography; LCA = left coronary artery; LO = left ostium; Min = minor <50%; RO = right ostium; Sig = significant >50%; SO = single orifice; − = negative findings; + = positive findings.

Coronary artery obstruction in patients with normal ECG and echocardiographic findings: prospective study. Of 105 asymptomatic patients operated on by the usual technique, 6 (5.7%, 95% CI 1.2% to 10.2%) had coronary artery lesions late after the arterial switch operation (range 4.7 to 9.7 years). All had negative exercise test results and normal findings on myocardial scintigraphy. Five patients had minor coronary artery lesions, and one had a left ostium occlusion with collateral vessels from the right coronary artery (Patient 30).

Single-orifice technique: coronary obstruction versus myocardial ischemia. Five of 11 patients with coronary artery obstruction had abnormal findings on the ECG and echocardiogram, whereas Patient 1, who underwent coronary angiography within 2 weeks of operation, had isolated ST-T changes. Five of 11 patients had no findings suggestive of myocardial ischemia but had coronary artery obstruction (Patients 11, 12, 14, 15, 16); three of them had myocardial perfusion defects on thallium single-photon emission computed tomographic imaging. The only right coronary stenosis in our series was found in this group.

Coronary artery obstruction versus early postoperative ischemia and delayed ischemia. Thirty-seven patients exhibited early postoperative ischemia. Of these, 27 patients recovered fully, with normal findings on the ECG and echocardiogram within the first month after the arterial switch operation. Coronary angiography was normal in 26 patients, with documented stretching of the circumflex artery in 1 patient (Patient 26). Ten patients never recovered and had persistent abnormal findings on the ECG and echocardiogram. All 10 of these patients had coronary artery lesions. Persistent ischemia was highly predictive of coronary artery lesion (chi-square 12.98, $p < 0.0001$).

Twenty-three patients developed delayed myocardial ischemia: 4 before hospital discharge after operation (severe coronary artery lesion in 3, [75%]: Patients 1, 5, 7); 11 within the first year after the arterial switch operation (coronary artery lesions in 4 [36%]: Patients 8, 9, 10, 13); and 8 were referred for ECG or echocardiographic anomalies, or both, during out-patient clinic follow-up (coronary artery lesions in 2 [25%]: Patients 18 and 25). Data are summarized in Table 1.

Outcome of patients with coronary artery obstruction. In two patients, coronary artery angiography was performed before late coronary death (Patients 7 and 8). Four of 30 patients underwent successful operation: 1 had mitral plasty of the mitral valve (Patient 24); 2 had left ostium enlargement (Patients 25 and 29); and 1 had internal mammary artery graft surgery (Patient 18). No other ischemic event occurred in the remaining 24 of 30 patients.

Discussion

Selective coronary artery angiography. Detailed evaluation of coronary artery translocation is of major importance after the arterial switch operation. However, expertise has to be gained for the documentation or reliable exclusion of coronary artery lesions in these patients (15,16). Prospective identification of inadequate coronary perfusion using myocardial scintigraphy has proved to be of uncertain clinical significance. Perfusion defects in this category of patients are frequent and are most likely related to the insult of open heart surgery rather than to the coronary artery lesions themselves (17). Although proximal occlusion of the coronary trunks can be shown by aortic root angiography (9), this technique may ignore mild stenosis or stretching of a coronary artery looping around one of the great vessel. In the present series, selective coronary angiography allowed identification of minor stenosis of the circumflex artery or left main coronary artery looping around one of the great vessel in four patients. Further, detailed morphology of the coronary artery and the collateral vessels in coronary artery obstruction cannot be obtained by aortic root angiograms.

Thus, we used selective coronary angiography to assess coronary artery anatomy after the arterial switch operation. This technique has proved to be safe and accurate in our laboratory, with >450 studies in pediatric patients.

Incidence of coronary artery obstruction. Because of the heterogeneity of our study group, it is not possible to estimate either the incidence of coronary artery lesions after the arterial switch operation nor the prevalence of late coronary artery obstruction. We studied patients who either had evidence of myocardial ischemia, were operated on using the single-orifice technique or had a minimal follow-up period of 5 years. The finding of coronary artery obstruction in 32.4% (95% CI 16.7% to 48.1% [11 of 35]) of the patients who underwent the single-orifice technique would lead to overestimation of the frequency of coronary artery lesions in the present series, as would exclusion of all asymptomatic patients with a follow-up period <5 years. Also, we did not perform coronary angiography in any of the five patients followed up at our institution who experienced sudden death within the first 6 months after operation. All five had coronary artery obstruction at autopsy, and three had undergone operation by the single-orifice technique. When the patients operated on with the usual technique with a follow-up of period at least 4 years ($n = 116$) were considered, we found coronary artery obstructions in 12. Of these 12 patients with obstructions, 4 had one coronary artery looping around the great vessels, and 3 had minor stenoses of the left main coronary artery. Because selective coronary artery angiograms increase detection of these lesions, the frequency of coronary events in our series appears to be higher than frequencies in published reports.

Coronary artery anatomy. Our findings suggest that both the technique of coronary artery translocation and the pattern of coronary artery anatomy are related to the occurrence of coronary artery obstruction after coronary transfer (18). Although the coronary artery patterns identified by Yacoub and Radley-Smith (14), which we used for classification do not fully embrace the great variability of the anatomic features of coronary artery in transposition of the great arteries (19), the present report emphasizes the higher risk of coronary artery occlusion or stretching when one of the coronary artery passes behind the pulmonary trunk, namely, types D and E. In addition, three patients had type C pattern with an initial intramural course of the left main coronary artery arising from the right-hand facing sinus (20). Two of these patients had coronary artery obstruction. Moreover, in one newborn infant with such coronary artery distribution, the left main coronary artery could not be reimplanted, and an internal mammary artery graft had to be created during the arterial switch operation. This, to our mind, suggests that atrial repair should be considered as an alternative to the arterial switch operation for such a coronary artery distribution.

Correlation with ECG and ultrasound anomalies. Abnormal ECG findings and associated echocardiographic signs of left ventricular ischemia are strong predictors of coronary artery obstruction whatever the perioperative history, coronary artery distribution or age. All patients with persistent ischemia on the ECG and echocardiogram from the postoperative period had significant coronary artery obstruction. Among these 10 patients with persistent ischemia, 4 had coronary artery angiography before 6 months (3 before hospital discharge) and exhibited mild coronary artery anomalies. Because the six remaining patients with permanent ischemia had occlusion of one coronary artery (left ostium in four, circumflex artery in two), we hypothesize that the translocation of the coronary arteries initiates an intimal proliferation that progresses gradually postoperatively and may lead to complete occlusion of the coronary artery (21). Clearly, this occlusion occurs when the coronary artery is distorted during the translocation. Considering that the majority of sudden deaths reported by others, and in our experience, occurs before 1 year after operation (22), it is then possible that in the survivors, the process of intimal proliferation has subsided by this time or that the growth of the coronary arteries or development of collateral vessels may overcome the stenosing process. Hence, whereas the six children with coronary artery occlusion and ECG and echocardiographic anomalies developed sufficient collateral vessels to weather early postoperative ischemia, the youngest four should be followed-up very closely because the fate of their mild stenosis is uncertain.

Conclusions. Selective coronary artery angiography is, in our opinion, the most accurate means of assessing the patency of coronary anastomoses after the arterial switch operation. Although our experience remains too limited to draw firm conclusions, our findings suggest that patients who exhibit myocardial ischemia should undergo coronary artery opacification. Because aortic root angiograms may ignore some peculiar coronary obstructions, a selective injection should be performed to exclude with certainty coronary lesions when suspected. Moreover, if revascularization is warranted, detailed anatomy of the obstructed coronary artery and collateral vessels must be obtained by selective angiograms. Precise diagnosis of coronary artery lesions after the arterial switch operation will help to clarify the pathogenesis, to develop adequate therapy and might indicate how to prevent coronary complications after operation. Sequential coronary artery angiography is required in infants with minor coronary artery lesions to determine the midterm patency of the affected coronary artery. This worrisome aspect of our results is the subject of an ongoing study in our institution.

References

1. Castaneda AR, Norwood WI, Jonas RA, Colan SD, Sanders SP, Lang P. Transposition of the great arteries and intact ventricular septum: anatomical repair in the neonates. Ann Thorac Surg 1984;38:438–43.
2. Bical O, Hazan E, Lecompte Y, et al. Anatomic correction of transposition of the great arteries associated with ventricular septal defect: midterm results in 50 patients. Circulation 1984;70:891–7.
3. Sidi D, Planché C, Kachaner J, et al. Anatomic correction of simple transposition of the great arteries in 50 neonates. Circulation 1987;75:429–35.
4. Planché C, Bruniaux J, Lacour-Gayet F, et al. Switch operation for transposition of the great arteries in neonates. J Thorac Cardiovasc Surg 1988;96: 354–63.
5. Kirklin JW, Blackstone EH, Tchervenkov CI, Castaneda AR, and the Congenital Heart Surgeon Society. Clinical outcomes after the arterial switch operation for transposition: patients, support, procedural, and institutional risk factors. Circulation 1992;86:1501–15.
6. Paillole C, Sidi D, Kachaner J, et al. Fate of the pulmonary artery after anatomic correction of simple transposition of great arteries in newborn infants. Circulation 1988;78:870–6.
7. Jenkins KJ, Hanley FL, Colan SD, Mayer JE Jr, Castaneda AR, Wernovsky G. Function of the anatomic pulmonary valve in the systemic circulation. Circulation 1991;84 Suppl III:III-173–9.
8. Dae MW. Myocardial perfusion after repair of transposition: is it worth the switch? J Am Coll Cardiol 1994;24:778–9.
9. Tanel R, Wernowsky G, Landzberg M, Perry S, Burke R. Coronary artery abnormalities detected at cardiac catheterization following the arterial switch operation for transposition of the great arteries. Am J Cardiol 1995;76:153–7.
10. Weindling SN, Wernovsky G, Colan SD, et al. Myocardial perfusion, function and exercise tolerance after the arterial switch operation. J Am Coll Cardiol 1994;23:424–33.
11. Bonnet D, Bonhoeffer P, Piéchaud JF, et al. Long term fate of the coronary arteries after the arterial switch operation in newborns with transposition of the great arteries. Heart 1996;76:274–9.
12. Serraf A, Lacour-Gayet F, Bruniaux J, et al. Anatomic correction of transposition of the great arteries in neonates. J Am Coll Cardiol 1993;22: 193–200.
13. Vouhé PR, Haydar A, Ouaknine R, et al. Arterial switch operation: a new technique of coronary transfer. Eur J Cardiothorac Surg 1994;8:74–8.
14. Yacoub MH, Radley-Smith R. Anatomy of the coronary arteries in transposition of the great arteries and methods for their transfer in anatomic correction. Thorax 1978;33:418–24.
15. Arensman FW, Sievers HH, Lange P, et al. Assessment of coronary and aortic anastomoses after anatomic correction of transposition of the great arteries. J Thorac Cardiovasc Surg 1985;90:597–604.
16. Wernovsky G, Hougen TJ, Walsh EP, et al. Midterm results after the arterial switch operation for transposition of the great arteries with intact ventricular septum: clinical, hemodynamic, echocardiographic, and electrophysiologic data. Circulation 1988;77:1333–44.
17. Hayes AM, Baker EJ, Kakadeker A, et al. Influence of anatomic correction for transposition of the great arteries on myocardial perfusion: radionuclide imaging with technetium-99m 2-methoxy isobutyl isonitrile. J Am Coll Cardiol 1994;24:769–77.
18. Kurosawa H, Imai Y, Kawada M. Coronary artery anatomy in regard to the arterial switch procedure. Cardiol Young 1991;1:54–62.
19. Anderson RH. Description of the origins and epicardial course of the coronary arteries in complete transposition. Cardiol Young 1991;1:11–2.
20. Asou T, Karl TR, Pawade A, Mee RB. Arterial switch: translocation of the intramural coronary artery. Ann Thorac Surg 1994;57:461–5.
21. Serruys PW, Luijten HE, Beatt KJ, et al. Incidence of restenosis after successful coronary angioplasty: a time related phenomenon. A quantitative angiographic study in 342 consecutive patients at 1, 2, 3 and 4 months. Circulation 1988;77:361–71.
22. Tsuda E, Imatika M, Yagihara T, et al. Late death after arterial switch operation for transposition of the great arteries. Am Heart J 1992;124: 1551–7.